# C0r0n@ 2 Inspect

Review and analysis of scientific articles related to experimental techniques and methods used in vaccines against c0r0n@v|rus, evidence, damage, hypotheses, opinions and challenges.

## Tuesday, August 10, 2021

**Food packaging with graphene oxide. Patents and studies**

**Reference**

KR20190070071A. 김립 . (2019). [Patent KR20190070071A]. Agricultural packaging film containing graphene. https://patents.google.com/patent/KR20190070071A/en

**Introduction**

1. Continuing with the investigation of graphene "G" and graphene oxide "GO" in fertilizers and phytosanitary products (see part 1 and 2 ), a patent has been found, which given its nature can provide relevant information to clarify other means of intoxication. This is the patent (KR20190070071A. 김립 . 2019) that defines the method of production and use of a film for food packaging.

**Facts**

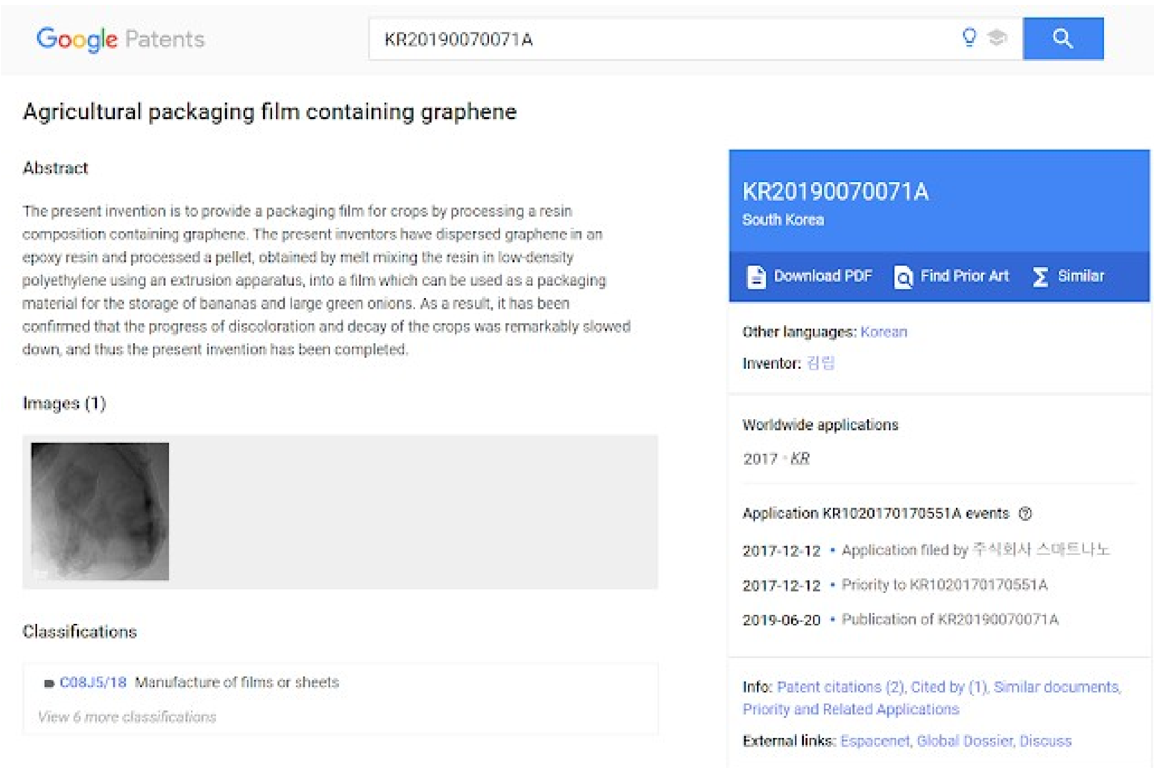


*Fig. 1. Patent (KR20190070071A. 김립 . 2019) on graphene plastic film for packaging agricultural products*

1. The Korean patent presents a plastic film composed of graphene that, according to the authors, helps to reduce the degradation of the products. This is explained as follows: " *The objective of the present invention is to provide a packaging film for crops by processing a resin composition containing graphene. The authors have dispersed graphene in an epoxy resin and processed a tablet, obtained by mixing in the state Cast the resin into low-density polyethylene using an extrusion apparatus, into a film that can be used as a packaging material for storing agricultural products*" The authors attribute properties to graphene to extend the useful life of food, however they do not mention the consequences for people's health, since it is a toxic and harmful substance, as it has been collected in this blog .
2. As the authors explain " *The composition of the packaging film is a special function in itself and has the effect of preventing the development of discoloration and decay of crops such as vegetables and fruits during distribution and storage ... there is a demand for a technology that can preserve the quality of the crop for a long time* . "This is possible because the graphene film that surrounds the food reduces the entry and exit of oxygen, which prevents its rotting for longer.
3. Next, the patent provides a very interesting detail " *It is common practice to incorporate various additives into the matrix resin for the expression of these functions. Examples of the additive include preservatives, nanomaterials, far infrared emitting materials and the like*.". Specifically the reference to far-infrared ray emitting materials, called in English" far-infrared-ray FIR. "Although the patent does not explain the usefulness of this characteristic, when investigating this property, it is found that the presence of a radiant FIR agent, increases antimicrobial activity, to improve hygiene and shelf life of food, see (Lee, JY; Kim , CH; Jung, HG; Shin, TG; Seo, JM; Lee, YR 2008). This is also corroborated by (Eom, SH; Park, HJ; Seo, DW; Kim, WW; Cho, DH 2009 | Leung, TK; Huang, PJ; Chen, YC; Lee, CM 2011). This is corroborated in the patent as follows "*The present invention provides a film for packaging cultures by reducing the oxygen output through a film and forming a composite material with a resin capable of emitting far infrared rays, thus minimizing the decrease in the transparency of the substrate* ".


*Fig. 2. Graphene sample in the patent plastic film (KR20190070071A. 김립 . 2019)*

4. In the tests carried out by the authors of the patent the following conclusion is highlighted " *As a result, it was confirmed that the discoloration and decomposition of the cultures packed with the film containing graphene were markedly delayed compared to the control film that did not contain graphene ... The banana samples packaged with a control film without graphene showed significant discoloration and deterioration of the skin after 14 days at room temperature, but in the case of films containing graphene, the discoloration was partial* . "Although the patent was requested in 2017 and published in 2019, in 2018 a news item related to this advance appeared, with the title " *Korean store presents a genius banana packaging to avoid overripe fruits* ", see (Barr, S. 2018).


*Fig. 3. Bananas that were probably packed with graphene film (Barr, S. 2018 )*

Although the issue of bananas could be anecdotal, this is not trivial since there are investigations that involve " *graphene oxide with chitosan* " as a preservative method, which is related to the purpose of the packaging media. It should be clarified that " *chitosan* " it is a compound polysaccharide compound, used in the agricultural context to combat pests, crop diseases, combat fungal infections, among other purposes. In the biomedical context it is used for its antiseptic properties (even combined with graphene or graphene oxide as in the cases cited here), for disinfection and wound healing (Choudhary, P.; Ramalingam, B.; Das, SK 2020). In the context of food packaging, it is used as a packaging surface due to its antimicrobial activity (Grande, CD ; Mangadlao, J.; Fan, J.; De Leon, A.; Delgado-Ospina, J.; Rojas, JG; Advincula, R. 2017), as well as in hydrogels (Konwar, A.; Kalita, S. ; Kotoky, J.; Chowdhury, D. 2016). Returning to the tests with bananas, the research of (Wang, H.; Qian, J.; Ding, F.2018) in which they work on the development of biodegradable plastic wrappers based on chitosan and graphene oxide, stating that "*Compared with pristine chitosan, chemical crosslinking based chitosan / graphene oxide films have the improved mechanical ability and oxygen barrier property. Stacks of graphene oxide and expanded graphite could also be added to chitosan to form films. The selectivity and safety demonstrated their potential as antimicrobial films for food storage* ."

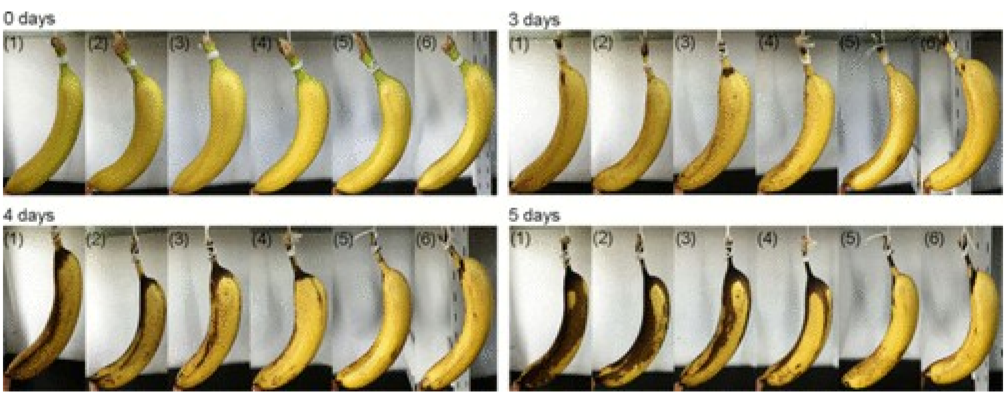


*Fig. 4. Comparative test of bananas with and without oxygen barrier film coating (Wang, H.; Qian, J.; Ding, F. 2018)*

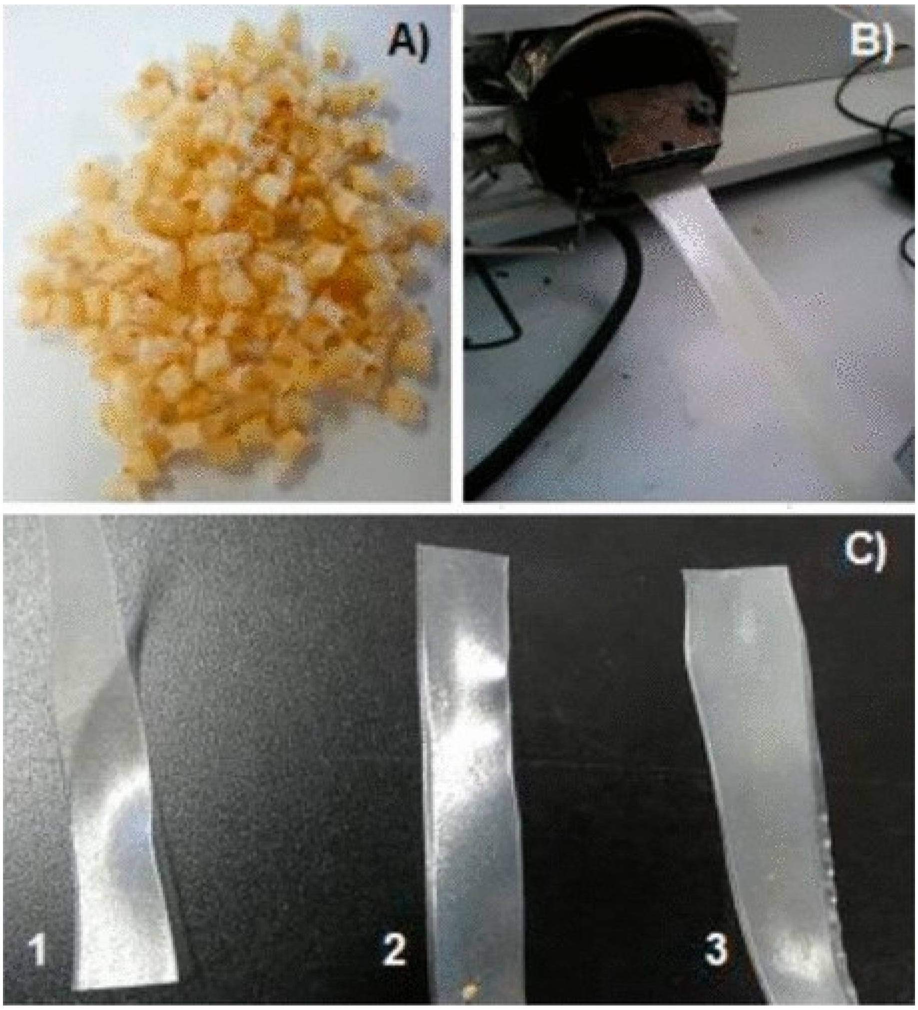


*Fig. 5. Compound chitosan granules and extrusion machine to create the packaging film (Wang, H.; Qian, J.; Ding, F. 2018)*

Another relevant statement of the experiment is relative to the pH level of the compound, and the ionization of the chitosan " *the chitosan was highly ionized by the poly (acrylic acid) counter ion and could attract more graphene oxide to the bulk film. Multilayer films demonstrated to have the combinational properties of the components and demonstrated that their inhibition of E.Coli (Escherichia Coli) and their antioxidant activity increased with the increase in the number of bilayers*". In this explanation the relationship between ionization and graphene oxide is clear. Other authors also agree on the use of graphene oxide in packaging products and processes, see (Venkateshaiah, A.; Cheong, JY; Habel, C.; Wacławek, S .; Lederer, T.; Cernik, M.; Agarwal, S. 2019 | Li, F.; Yu, HY; Wang, YY; Zhou, Y.; Zhang, H.; Yao, JM; Tam, KC 2019) .

5. To finish the analysis of the patent referred to in the entry (KR20190070071A. 김립 . 2019), it is worth reviewing the claims section, where it is indicated that the graphene used in the film has an average thickness of 1 to 20 atomic layers. The rest of the compounds are polyethylene resin, polypropylene, polyethylene terephthalate and the graphene already mentioned.

**Other studies**

1. In addition to the patent referred to in the entry, there are dozens of investigations related to materials for food packaging that use graphene G or graphene oxide GO. A recent example is that of (Cheng, Y.; Dong, H.; Wu, Y.; Xiao, K. 2021) who develop a material for vacuum packaging containing amidated graphene oxide / sulfonated polyether ether ketone, also known by its acronym AGO / SPEEK, oriented to the storage of cherry tomatoes.

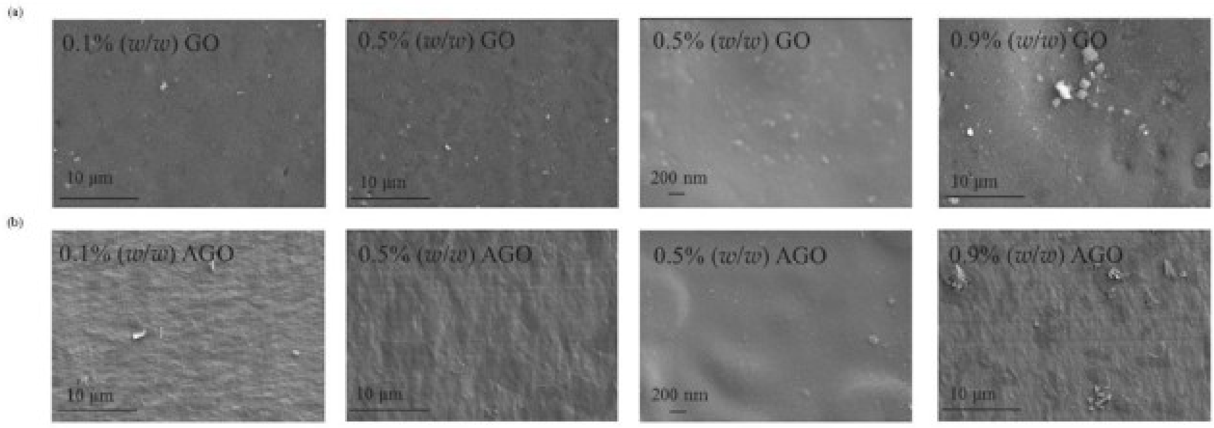


*Fig. 6. Microscopy of the AGO / SPEEK used for the packaging of tomatoes. (Cheng, Y.; Dong, H.; Wu, Y.; Xiao, K. 2021)*

2. Returning to the banana packaging experiments, there is the study by ( Chowdhury, S.; Teoh, YL; Ong, KM; Zaidi, NSR; Mah, SK 2020 ) that presents the development of polyvinyl alcohol PVA films with oxide of graphene GO. The authors state that "*PVA-GA-GO film was also shown to possess bacterial cytotoxicity by forming a 10 mm zone of inhibition towards E. coli, which can be assessed for having moderate antibacterial activity. The bacterial cytotoxicity of the PVA-GA-GO film is attributed to the insertion of the GO nanoplate into the cell membrane. Due to the shape of the sharp, blade-like edges that GO possesses, it could invade and disrupt the phospholipids of E.Coli (Escherichia Coli) membranes, leading to the formation of nanoscale cavities and holes* . "It is interesting, since graphene oxide has the peculiarity of penetrating and coming into contact with the cells of the bacteria, depositing and accumulating; the authors confirm this as follows"*In addition, GO has a higher functional group density and is physically small, thus providing more opportunities to come into contact and interact with bacterial cells, resulting in cell deposition. Through direct contact, graphene nanosheets can stimulate membrane stress by destroying cell membranes and ultimately lead to cell death*. " If GO graphene oxide is capable of causing cell death in bacteria, It could also do it with human cells, in fact this is affirmed in the works of (Mittal, S.; Kumar, V.; Dhiman, N.; Chauhan, LKS; Pasricha, R.; Pandey, AK 2016 | Lim, MH; Jeung, IC; Jeong, J.; Yoon, SJ; Lee, SH; Park, J.; Min, JK 2016 | Gurunathan, S .; Arsalan-Iqbal, M .; Qasim, M .; Park, CH; Yoo, H .; Hwang, JH; Hong, K. 2019 | Palmieri, V .; Lauriola, MC; Ciasca, G .; Conti, C .; De-Spirito, M .; Papi, M. 2017 | Chen, L .; Hu, P .; Zhang, L .; Huang, S .; Luo, L .; Huang, C. 2012 | Seabra, AB; Paula, AJ; de-Lima, R .; Alves, OL; Durán, N. 2014) among others.

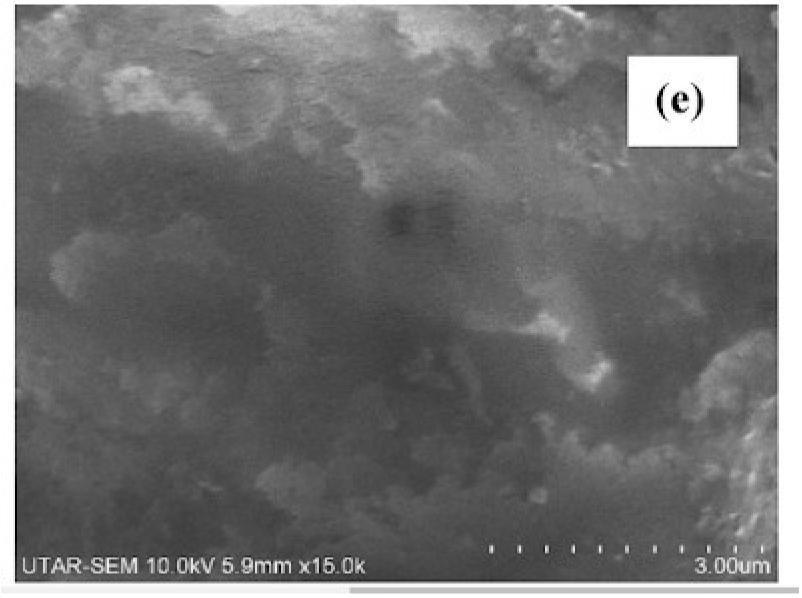


*Fig. 7. Graphene oxide compound PVA-GA-GO used in the research (Chowdhury, S.; Teoh, YL; Ong, KM; Zaidi, NSR; Mah, SK 2020)*

3. The work of ( Ghanem, AF; Youssef, AM; Rehim, MHA 2020 ) is of interest for introducing graphene oxide in polystyrene packaging. This is stated verbatim as follows: " *Hydrophilic graphene oxide (GO), prepared by the Hummer method, was surface grafted with hydrophobic poly (4-vinylbenzyl chloride), p (VBC), by a Radical polymerization in situ. Graphene oxide / poly (4-vinylbenzyl chloride), GP (VBC), was then dispersed in the polystyrene matrix to obtain thin nanocomposite films with different filling ratios (5%, 10%, 15%, 20% and 25%) of the weight*"This means that graphene oxide is applied to any polystyrene product that is in contact with food, for example plastic tubs, heat-sealable lids, jars, foam (plastic foams), take-out containers, in short, plastic food containers.

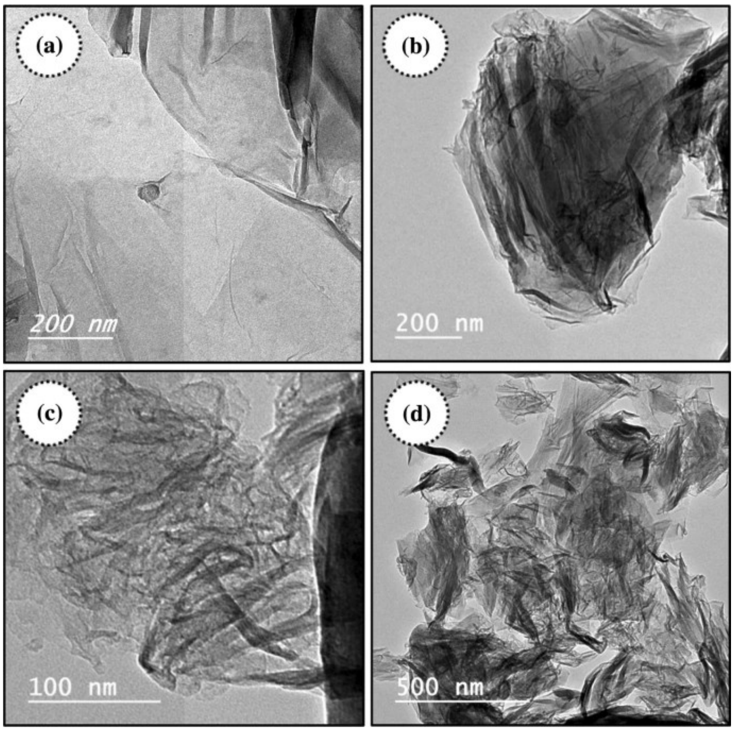


*Fig. 8. Graphene oxide samples used in research development (Ghanem, AF; Youssef, AM; Rehim, MHA 2020)*

4. The research by (Goh, K.; Heising, JK; Yuan, Y.; Karahan, HE; Wei, L.; Zhai, S.; Chen, Y. 2016) uses poly (lactic acid) PLA together with oxide reduced graphene "rGO", to improve the packaging properties and solve the problems of the barrier to water vapor and oxygen that many petroleum derivatives present, therefore " *To address this problem, we designed a composite film of PLA-graphene with sandwich architecture, which uses a waterproof reduced graphene oxide (rGO) as a central barrier and commercial PLA films as an outer protective encapsulation . "The authors conclude that"the large lateral dimension of rGO and the small interlayer gap between the rGO sheets have created an extensive and tortuous diffusion path, which is up to 1,450 times the thickness of the rGO barrier ... the interleaved architecture has endowed the film PLA-rGO composite with good processability, which increases the manageability of the film and its ability to adapt. Simulations using PLA - rGO composite food packaging film for edible oil and potato chips also show an at least eight-fold extension in shelf life of these oxygen and moisture sensitive food products.* "As can be seen in Figure 9, the graphene oxide barrier acts as a waterproofing agent for the oxygen contained within the bag or container with the food, increasing the useful life of the food.

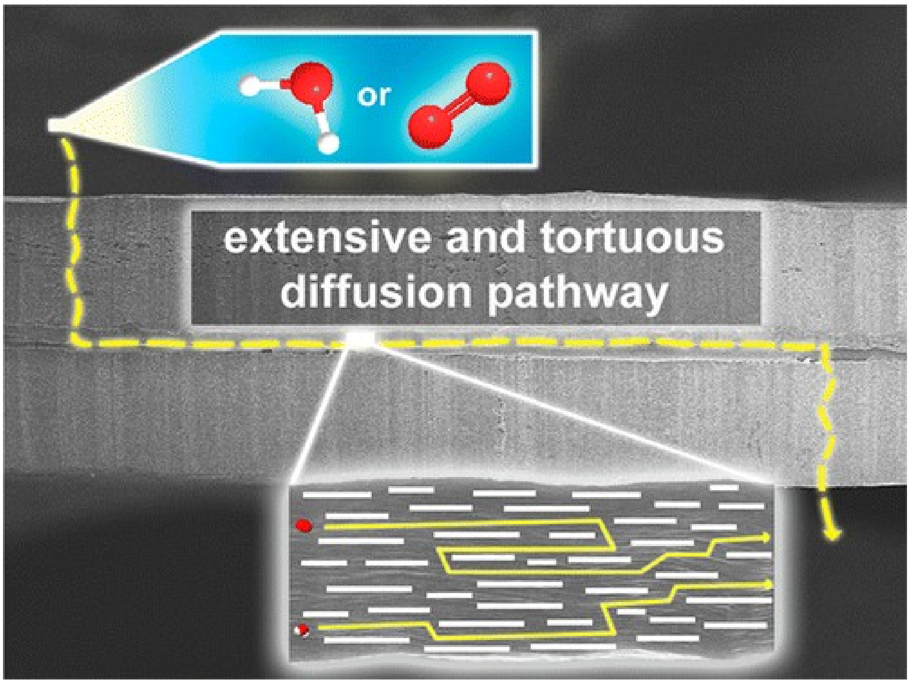


*Fig. 9. Section image of the PLA-rGO film developed in the research (Goh, K.; Heising, JK; Yuan, Y.; Karahan, HE; Wei, L.; Zhai, S.; Chen, Y 2016)*

Other authors ( Huang, HD; Ren, PG; Xu, JZ; Xu, L.; Zhong, GJ; Hsiao, BS; Li, ZM 2014 ), have also used the same poly (lactic acid) PLA approach, although combined with graphene oxide *nanosheets " GONS "*. Among the most outstanding results " *A great decrease was obtained in the gas permeability coefficients of the PLA films, where the permeability coefficients to O2 and CO2 were reduced respectively, by approximately 45% and 68% with a load of GONS down 1.37% of volume* ". The PLA-GONS combination has the peculiarity that it can protect food from ultraviolet light, as they comment "*the incorporation of GONS could effectively block the transmission of ultraviolet light in nanocomposite films and provide the PLA matrix with excellent thermal stability* ", highlighting the suitability of the material for the" *manufacture of large-scale high barrier films in the packaging industry* ".

5. The development of environmentally biodegradable materials for food packaging has also been investigated ( Manikandan, NA; Pakshirajan, K.; Pugazhenthi, G. 2020 ). In this work a material of polyhydroxybutyrate PHB (semi-crystalline thermoplastic biopolymer) and graphene "G" is created. Like the aforementioned studies, the mechanical and barrier properties for the protection and durability of food are evaluated. Interestingly, the authors mention the cytotoxicity of graphene stating that " *The nanocomposite PHB / Gr-NPs is less cytotoxic and highly biodegradable by soil biomes* ", adding that "*increases shelf life four times, after simulating foods sensitive to moisture and oxygen (potato chips and dairy products*) . "

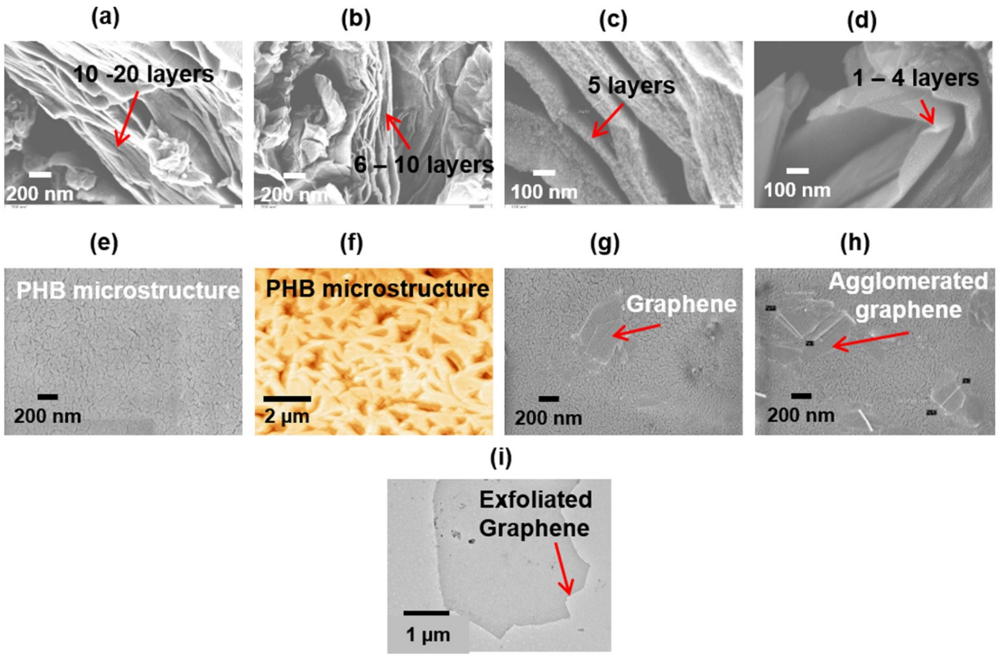


*Fig. 10. Microscopy of the material used in the graphene PHB-Gr-NPs research (Manikandan, NA; Pakshirajan, K.; Pugazhenthi, G. 2020)*

**Reviews**

1. It has been shown that graphene "G", graphene oxide "GO", even reduced graphene oxide "rGO", could be widely used in all types of food packaging, in the form of plastic film, to extend the life of food, as shown in the scientific literature (KR20190070071A. 김립 . 2019 | Venkateshaiah, A.; Cheong, JY; Habel, C.; Wacławek, S.; Lederer, T.; Cernik, M.; Agarwal, S. 2019 | Li, F .; Yu, HY; Wang, YY; Zhou, Y.; Zhang, H.; Yao, JM; Tam, KC 2019 | Cheng, Y.; Dong, H.; Wu, Y.; Xiao, K. 2021 | Chowdhury, S.; Teoh, YL; Ong, KM; Zaidi, NSR; Mah, SK 2020 | Ghanem, AF; Youssef, AM; Rehim, MHA 2020 | Goh, K.; Heising, JK; Yuan, Y.; Karahan , HE; Wei, L.; Zhai, S.; Chen, Y. 2016 | Huang, HD; Ren, PG; Xu, JZ; Xu, L.; Zhong, GJ; Hsiao, BS; Li, ZM 2014 | Manikandan, NA; Pakshirajan, K .; Pugazhenthi, G. 2020 | Yu, J .; Ruengkajorn, K .; Crivoi, DG; Chen, C .; Buffet, JC; O'Hare, D. 2019 | Terzioglu, P .; Altin, Y .; Kalemtas, A .; Bedeloglu, AC 2020) which can also be found with the query "graphene oxide" "food" "film" "packaging" .
2. Graphene could also be used together with chitosan (or chitosan), or with other components, to make bandages, dressings and products for wound healing ( Fan, Z.; Liu, B.; Wang, J.; Zhang, S.; Lin , Q.; Gong, P.; Yang, S. 2014 | Lu, B.; Li, T.; Zhao, H.; Li, X.; Gao, C.; Zhang, S.; Xie, E. 2012). The use of graphene oxide in hydrogels, intended for hygiene, is also demonstrated (Konwar, A.; Kalita, S.; Kotoky, J.; Chowdhury, D. 2016 | Papi, M.; Palmieri, V.; Bugli, F .;

De Spirito, M.; Sanguinetti, M.; Ciancico, C.; Conti, C. 2016 | Wang, X.; Liu, Z.; Ye, X.; Hu, K.; Zhong, H.; Yuan , X.; Guo, Z. 2015 | Jafari, Z.; Rad, AS; Baharfar, R.; Asghari, S.; Esfahani, MR 2020 | Cheng, W.; Chen, Y.; Teng, L.; Lu , B.; Ren, L.; Wang, Y. 2018). All products derived from these applications could contain graphene and affect human health.

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5. The analysis of plastic films and food packaging is recommended, in order to reliably verify the presence of graphene, so that they are withdrawn or avoided by consumers. There is a probability that the graphene contained in the packaging will contaminate food by contact and deposition, after its degradation, as well as the people who handle it. Therefore, its recognition in the laboratory is essential.
6. If the presence of graphene in these materials for food packaging is confirmed, a new contamination route would be demonstrated, as well as another explanation for the magnetic phenomenon in food. In this way, food could acquire these properties by being in permanent contact for days, as well as the more than possible effect of ionization on graphene. This would also explain the magnetic properties of the containers and of the people who were in continuous contact. In fact, transdermal penetration, or what is the same, the penetration of graphene oxide with and without chitosan through the skin, is widely demonstrated (Justin, R.; Chen, B. 2014), considering a method for the drug and drug delivery , see also the case of administration of " *ondansetron*"(drug for the treatment of nausea and vomiting) in animals ( Li, H.; Jia, Y.; Liu, C. 2020 ). In relation to the transdermal properties of graphene oxide, more 100 related studies can be found that support this statement, see the query "graphene oxide" intitle: "transdermal"

**Bibliography**


1. Barr, S. (2018). Korean store unveils 'genius' banana packaging to avoid overripe fruit. https://www.independent.co.uk/life-style/food-and-drink/banana-packaging-ripe-hack-korea-supermarket-e-mart-ssg-plastic-waste-a8485066.html [Note: in case of not accessing the information due to redirection, open with Tor browser ]
2. Chen, L .; Hu, P .; Zhang, L .; Huang, S .; Luo, L .; Huang, C. (2012). Toxicity of graphene oxide and multi-walled carbon nanotubes against human cells and zebrafish. Science China Chemistry, 55 (10), pp. 2209-2216. https://doi.org/10.1007/s11426-012-4620-z
3. Cheng, W .; Chen, Y .; Teng, L .; Lu, B .; Ren, L .; Wang, Y. (2018). Antimicrobial colloidal hydrogels assembled by graphene oxide and thermo-sensitive nanogels for cell encapsulation. Journal of colloid and interface science, 513, pp. 314-323. https://doi.org/10.1016/j.jcis.2017.11.018

4. Cheng, Y .; Dong, H .; Wu, Y .; Xiao, K. (2021). Preparation of an Amidated Graphene Oxide / Sulfonated Poly Ether Ether Ketone (AGO / SPEEK) Modified Atmosphere Packaging for the Storage of Cherry Tomatoes. Foods, 10 (3), 552. https://doi.org/10.3390/foods10030552
5. Choudhary, P .; Ramalingam, B .; Das, SK (2020). Fabrication of Chitosan-Reinforced Multifunctional Graphene Nanocomposite as Antibacterial Scaffolds for Hemorrhage Control and Wound-Healing Application. ACS Biomaterials Science & Engineering, 6 (10), pp. 5911-5929. https://doi.org/10.1021/acsbiomaterials.0c00923
6. Chowdhury, S .; Teoh, YL; Ong, KM; Zaidi, NSR; Mah, SK (2020). Poly (vinyl) alcohol crosslinked composite packaging film containing gold nanoparticles on shelf life extension of banana. Food Packaging and Shelf Life, 24, 100463. https://doi.org/10.1016/j.fpsl.2020.100463
7. Eom, SH; Park, HJ; Seo, DW; Kim, WW; Cho, DH (2009). Stimulating effects of far infrared radiation on the release of antioxidant phenolics in grapes. Food Science and Biotechnology, 18 (2), pp. 362-366. https://www.koreascience.or.kr/article/JAKO200917639069310.page
8. Konwar, A .; Kalita, S .; Kotoky, J .; Chowdhury, D. (2016). Chitosan - Iron Oxide Coated Graphene Oxide Nanocomposite Hydrogel: A Robust and Soft Antimicrobial Biofilm. ACS Applied Material Interfaces, 8 (32), pp. 20625-20634. https://doi.org/10.1021/acsami.6b07510
9. KR20190070071A. 김립 . (2019). [Patent KR20190070071A]. Agricultural packaging film containing graphene. https://patents.google.com/patent/KR20190070071A/en
10. Fan, Z .; Liu, B .; Wang, J .; Zhang, S .; Lin, Q .; Gong, P .; Yang, S. (2014). A new Ag / graphene polymer hydrogel based wound dressing: effectively kills bacteria and accelerates wound healing. Advanced functional materials, 24 (25), pp. 3933-3943. https://doi.org/10.1002/adfm.201304202
11. Ghanem, AF; Youssef, AM; Rehim, MHA (2020). Hydrophobically modified graphene oxide as a barrier and antibacterial agent for polystyrene packaging. Journal of Materials Science, 55 (11), pp. 4685-4700. https://doi.org/10.1007/s10853-019-04333-7
12. Goh, K .; Heising, JK; Yuan, Y .; Karahan, HE; Wei, L .; Zhai, S .; Chen, Y. (2016). Sandwich-architectured poly (lactic acid) –graphene composite food packaging films. ACS applied materials & interfaces, 8 (15), pp. 9994-10004. https://doi.org/10.1021/acsami.6b02498
13. Large, CD; Mangadlao, J .; Fan, J .; De Leon, A .; Delgado - Ospina, J .; Rojas, JG; Advincula, R. (2017). Chitosan Cross-Linked Graphene Oxide Nanocomposite Films with Antimicrobial Activity for Application in Food Industry. In Macromolecular symposia. 374 (1), pp. 1600114. https://doi.org/10.1002/masy.201600114
14. Gurunathan, S .; Arsalan-Iqbal, M .; Qasim, M .; Park, CH; Yoo, H .; Hwang, JH; Hong, K. (2019). Evaluation of Graphene Oxide Induced Cellular Toxicity and Transcriptome Analysis in Human Embryonic Kidney Cells. Nanomaterials, 9 (7), 969. https://doi.org/10.3390/nano9070969
15. Huang, HD; Ren, PG; Xu, JZ; Xu, L .; Zhong, GJ; Hsiao, BS; Li, ZM (2014). Improved barrier properties of poly (lactic acid) with randomly dispersed graphene oxide nanosheets. Journal of Membrane Science, 464, pp. 110-118. https://doi.org/10.1016/j.memsci.2014.04.009

16. Jafari, Z .; Rad, AS; Baharfar, R .; Asghari, S .; Esfahani, MR (2020). Synthesis and application of chitosan / tripolyphosphate / graphene oxide hydrogel as a new drug delivery system for Sumatriptan Succinate. Journal of Molecular Liquids, 315, 113835. https://doi.org/10.1016/j.molliq.2020.113835
17. Justin, R .; Chen, B. (2014). Strong and conductive chitosan-reduced graphene oxide nanocomposites for transdermal drug delivery. Journal of Materials Chemistry B, 2 (24), pp. 3759-3770. https://doi.org/10.1039/C4TB00390J
18. Lee, JY; Kim, CH; Jung, HG; Shin, TG; Seo, JM; Lee, YR (2008). Emission of far-infrared ray in packaging paper. Journal of Korea Technical Association of the Pulp and Paper Industry, 40 (5), pp. 47-52. https://www.koreascience.or.kr/article/JAKO200804748553280.page
19. Leung, TK; Huang, PJ; Chen, YC; Lee, CM (2011). Physical-chemical Test Platform for Room Temperature, Far-infrared Ray Emitting Ceramic Materials (cFIR). Journal of the Chinese Chemical Society, 58 (5), pp. 653-658. https://doi.org/10.1002/jccs.201190101
20. Li, F .; Yu, HY; Wang, YY; Zhou, Y .; Zhang, H .; Yao, JM; Tam, KC (2019). Natural biodegradable poly (3-hydroxybutyrate-co-3-hydroxyvalerate) nanocomposites with multifunctional cellulose nanocrystals / graphene oxide hybrids for high-performance food packaging. Journal of agricultural and food chemistry, 67 (39), pp. 10954-10967. https://doi.org/10.1021/acs.jafc.9b03110
21. Li, H .; Jia, Y .; Liu, C. (2020). Pluronic® F127 stabilized reduced graphene oxide hydrogel for transdermal delivery of ondansetron: Ex vivo and animal studies. Colloids and Surfaces B: Biointerfaces, 195, 111259. https://doi.org/10.1016/j.colsurfb.2020.111259
22. Lim, MH; Jeung, IC; Jeong, J .; Yoon, SJ; Lee, SH; Park, J .; Min, JK (2016). Graphene oxide induces apoptotic cell death in endothelial cells by activating autophagy via calcium-dependent phosphorylation of c-Jun N-terminal kinases. Acta biomaterialia, 46, pp. 191-203. https://doi.org/10.1016/j.actbio.2016.09.018
23. Lu, B .; Li, T .; Zhao, H .; Li, X .; Gao, C .; Zhang, S .; Xie, E. (2012). Graphene-based composite materials beneficial to wound healing. Nanoscale, 4 (9), pp. 2978-2982. https://doi.org/10.1039/C2NR11958G
24. Manikandan, NA; Pakshirajan, K .; Pugazhenthi, G. (2020). Preparation and characterization of environmentally safe and highly biodegradable microbial polyhydroxybutyrate (PHB) based graphene nanocomposites for potential food packaging applications. International journal of biological macromolecules, 154, pp. 866-877. https://doi.org/10.1016/j.ijbiomac.2020.03.084
25. Mittal, S .; Kumar, V .; Dhiman, N .; Chauhan, LKS; Pasricha, R .; Pandey, AK (2016). Physico-chemical properties based on the differential toxicity of graphene oxide / reduced graphene oxide in human lung cells mediated by oxidative stress. Scientific reports, 6 (1), pp. 1-16. https://doi.org/10.1038/srep39548
26. Palmieri, V .; Lauriola, MC; Ciasca, G .; Conti, C .; De-Spirito, M .; Papi, M. (2017). The graphene oxide contradictory effects against human pathogens. Nanotechnology, 28 (15), 152001. https://doi.org/10.1088/1361-6528/aa6150
27. Daddy, M .; Palmieri, V .; Bugli, F .; De Spirito, M .; Sanguinetti, M .; Cyancico, C .; Conti, C. (2016). Biomimetic antimicrobial cloak by graphene-oxide agar hydrogel. Scientific reports, 6 (1), pp. 1-7. https://doi.org/10.1038/s41598-016-0010-7
28. Seabra, AB; Paula, AJ; de-Lima, R .; Alves, OL; Durán, N. (2014). Nanotoxicity of Graphene and Graphene Oxide. Chemical research in toxicology, 27 (2), pp. 159-168. https://doi.org/10.1021/tx400385x

29. Terzioglu, P .; Altin, Y .; Kalemtas, A .; Bedeloglu, AC (2020). Graphene oxide and zinc oxide decorated chitosan nanocomposite biofilms for packaging applications. Journal of Polymer Engineering, 40 (2), pp. 152-157. http://doi.org/10.1515/polyeng-2019-0240
30. Venkateshaiah, A .; Cheong, JY; Habel, C .; Wacławek, S .; Lederer, T .; Cernik, M .; Agarwal, S. (2019). Tree gum - graphene oxide nanocomposite films as gas barriers. ACS Applied Nano Materials, 3 (1), pp. 633-640. https://doi.org/10.1021/acsanm.9b02166
31. Wang, H .; Qian, J .; Ding, F. (2018). Emerging chitosan-based films for food packaging applications. Journal of agricultural and food chemistry, 66 (2), pp. 395-413. https://doi.org/10.1021/acs.jafc.7b04528
32. Wang, X .; Liu, Z .; Ye, X .; Hu, K .; Zhong, H .; Yuan, X .; Guo, Z. (2015). A simple one-pot method for two types of graphene oxide-based hydrogels with broad spectrum antimicrobial properties. Journal of Chemical Engineering, 260, pp. 331-337. https://doi.org/10.1016/j.cej.2014.08.102
33. Yu, J .; Ruengkajorn, K .; Crivoi, DG; Chen, C .; Buffet, JC; O'Hare, D. (2019). High gas barrier coating using non-toxic nanosheet dispersions for flexible food packaging film. Nature communications, 10 (1), pp. 1-8. https://doi.org/10.1038/s41467-019-10362-2